Gender gaps in mathematics, science and reading achievements in Muslim countries: a quantile regression approach

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Using quantile regression analyses, this study examines gender gaps in mathematics, science, and reading in Azerbaijan, Indonesia, Jordan, the Kyrgyz Republic, Qatar, Tunisia, and Turkey among 15-year-old students. The analyses show that girls in Azerbaijan achieve as well as boys in mathematics and science and overachieve in reading. In Jordan, girls achieve as well as boys in all subjects. In Qatar and Turkey, girls underachieve in mathematics, achieve as well as boys in science and overachieve in reading. In Indonesia, the Kyrgyz Republic, and Tunisia, girls underachieve in mathematics and science but overachieve in reading. On the basis of the analyses, two generalizations can be made. First, key country-level economic and social characteristics appear unrelated to achievement gender gaps. Second, the overachievement of girls in reading and underachievement in mathematics and science are similar to findings from non-Muslim industrialized countries.

Keywords: educational economics; gender; human capital; Muslim

JEL Classifications: I20, J10, J16, O12, O15, O53, O55, O57

1. Introduction

According to traditional arguments, unfavorable cultural, social, and economic conditions undermine the academic achievement of girls relative to boys. For example, it is argued that Islamic culture – with the emphasis on modesty and gender segregation – discourages female education and labor market participation in predominantly Muslim countries (King and Hill 1998). Like most other societies, girls in Muslim countries also face weaker adult labor market prospects than boys, and family and social pressures to marry early and fully care for their large-sized families (Lewis and Lockheed 2006). Past research has supported these assertions on the cultural, social, and economic disadvantages. In a cross-country study, Dollar and Gatti (1999) found larger pro-male gaps in secondary educational attainment in Muslim countries than non-Muslim countries, holding other country-level characteristics constant. Using public opinion data from 66 countries, Guiso, Sapienza, and Zingales (2003) concluded that Muslims are more likely to believe that men deserve university education more than women, and that men deserve scarce jobs more than women. Researchers have also

documented significant pro-male gaps in employment rates and earnings among comparably educated and experienced workers (e.g. King and Hill 1998).

Recent cultural, social, and economic changes in Muslim countries, however, should result in better academic achievement from girls. In particular, revised interpretations of the Qur'an are leading to advances in women's rights in marriage and opportunities in the labor market (Barlas 2002). Furthermore, Muslim countries are experiencing economic development, with expanding service sectors and new work opportunities for women (Haddad and Esposito 1998; Haghighat-Sordellini 2010).

In the face of improving cultural, social, and economic conditions, do girls in Muslim countries underachieve academically relative to boys? More formally, are there pro-male academic gender gaps in Muslim countries even if girls have similar personal, family, and school characteristics as boys? Using quantile regression analyses, this study examines the nature of gender gaps in mathematics, science, and reading achievement among 15-year-old female and male students in seven predominantly Muslim countries: Azerbaijan, Indonesia, Jordan, the Kyrgyz Republic, Qatar, Tunisia, and Turkey.

This study makes two contributions to the literature on the economics of education in predominantly Muslim countries. First, this is among the first studies to examine gender gaps across subjects; much of the existing research examines gender gaps in enrolment and attainment (years of education).[1] Mathematics, science, and reading achievements are examined because research from industrialized countries shows that the direction and magnitude of gender gaps in achievement vary by academic subject (Arnot, David, and Weiner 1999; Dywer 1973; Eccles and Jacobs 1986; Hyde et al. 2008; Mickelson 1989; Weinburgh 1995). Second, this is the only study to use quantile regression analyses to understand achievement gender gaps in Muslim countries, which provides insight into how girls compare to boys in low-, median-, and high-achieving student groups. In particular, recent quantile regression analyses from industrialized countries indicate that the direction and magnitude of gender gaps may vary across the achievement distribution (Husain and Millimet 2008). For example, there may be a small pro-male gap in reading among low-achievers, but a pro-female gap among high-achievers; OLS would only provide the average difference and not detect the differences in direction and magnitude across achievement quantiles.

2.   Background

The conceptual model for this study draws from the human capital model established by Becker (1964). Using this model, academic achievement is determined by student expectations about benefits and costs of a certain level of educational achievement after controlling for other student, family, and school characteristics. For example, if a girl expects to marry late, have few children, and obtain a career that rewards her academic achievement, then she expects higher returns to academic achievement and therefore is likely to achieve better, holding all other characteristics constant. Girls' expectations are based on observing siblings and friends who are in their late teens and early 30s, and who have similar backgrounds to their own (Wilson 2001). In addition, there is a stronger incentive to strive academically if cultural, social, and economic conditions for women are improving rapidly, as in the case of the much of the Muslim world.

The seven predominantly Muslim countries considered in this study represent various world regions: Central Asia (Azerbaijan and the Kyrgyz Republic), Eurasia (Turkey), Middle East and North Africa (Jordan, Qatar, and Tunisia), and Southeast Asia (Indonesia). Together, these seven countries account for about one-quarter of the

total population in the 48 Muslim majority countries (Population Reference Bureau 2008). A useful source for assessing the economic and social conditions that affect girls' academic achievement is the *Global Gender Gap Report* (Hausman, Tyson, and Zahidi 2007) produced annually by the World Economic Forum. Table 1 draws from the *Global Gender Gap Report 2007* and presents population, income, growth, education, labor market data for the seven countries in the year 2006. Qatar is the least populated country, with 840,000 people. Next smallest are the Kyrgyz Republic with 5.4 million and Jordan with 5.6 million people. Azerbaijan has 8.7 million people, and Tunisia has 10.3 million people. Among the seven countries considered in this study, Turkey's population is second largest with 73.4 million people. With a total population size of 225.6 million, Indonesia is the most populous predominantly Muslim country in the world.

The purchasing power parity adjusted per capita incomes vary across the countries and indicate the different levels of economic development: $6086 in Azerbaijan, $3348 in Indonesia, $4485 in Jordan, $1990 in the Kyrgyz Republic, $70,716 in oil-rich Qatar, $2970 in Tunisia, and $5400 in Turkey. Higher income is a key indicator of economic development and is typically associated with supportive economic, social, and cultural conditions for girls and women (Hausman, Tyson, and Zahidi 2007).

The economic growth rates are over 4% in Indonesia (4.4%), Jordan (4%), Tunisia (4.1%), and Turkey (4.8%) and lower in Azerbaijan (3.1%), the Kyrgyz Republic (1.6%), and Qatar (1.4%). Higher growth rates may encourage girls' academic achievement because economic growth is typically accompanied by a growth in the services sector, where there are better employment opportunities for females than in the agriculture and manufacturing sectors (Mammen and Paxson 2000).

Table 1 also shows that all of the countries are close to achieving gender parity in secondary educational attainment. The narrow gender gaps are indicative of how much society has changed. Historically, girls in Muslim countries were withdrawn from secondary school after reaching puberty (UNESCO 2003, 124). Gender parity in enrolment, however, does not imply gender parity in mathematics, science, and reading achievement.[2]

The age of marriage and fertility rates affect the manner in which women can participate in the labor force. A higher age of marriage and fewer children not only increase the potential number of years on the labor market but also can allow women to pursue careers rather than jobs. Holding all other factors constant, a higher age of marriage and lower fertility rate is likely to encourage girls' academic achievement because of increased time in the labor market and higher lifetime earnings. The age of marriage is lowest in Turkey (22 years) and highest in Tunisia (27 years); elsewhere, the fertility rates are close to the population replacement rate of two. These figures reflect the substantial decline in fertility rates compared to those observed in previous cohorts of women (Population Resource Center 2003). Consequently, girls in each of the Muslim countries may now expect to marry later and have fewer children; since both these factors increase lifetime labor market earnings from a given level of academic achievement, girls will be motivated to put more effort academically so as to achieve more similarly to boys. In short, holding all else constant, rising marriage age and shrinking fertility rates increase expected net benefits of education and encourage academic achievement.

Table 1 indicates significant labor market gender gaps in all seven countries. Gender parity in labor force participation is highest in Azerbaijan (0.86) and lowest in Turkey (0.36). Similarly, wage equality for similar work is highest in Azerbaijan

Table 1. Economic and social conditions by country, 2006.

Country	Population (millions)	GDP (PPP US$) per capita	GDP growth rate (%)	Gender parity ratio in secondary education (female/male)	Gender parity ratio in labor force particip. (female/male)	Wage equality for similar work (female/male)	Average age of marriage	Fertility rate (births per woman)
Azerbaijan	8.57	6,086	3.1	0.96	0.86	0.84	24	1.70
Indonesia	225.63	3,348	4.4	1.00	0.61	0.74	23	2.20
Jordan	5.57	4,485	4.0	1.00	0.37	0.72	25	3.20
Kyrgyz Republic	5.24	1,757	1.6	1.00	0.77	0.70	22	2.50
Qatar	0.84	70,716	1.4	0.99	0.42	0.73	—	2.70
Tunisia	10.25	6,648	4.1	1.00	0.41	0.83	27	1.90
Turkey	73.89	8,157	4.8	0.86	0.36	0.61	22	2.20

Note: Ratios are obtained by dividing female figure by male figure.
Source: Gender Gap Report 2008 (Hausmann, Tyson, and Zahidi 2008), except GDP growth rate from the Word Bank's World Development Indicators 2007 (http:// databank.worldbank.org). All figures for Kyrgyz Republic are obtained from the World Development Indicators. All figures are for the year 2006. Growth rate is for 2005–2006.

(0.84) and lowest in Turkey (0.61). As discussed earlier, this gap in labor market opportunities and compensation may discourage girls' academic achievement, causing pro-male gender gaps.

Despite the differences, the countries considered in this study are not fully representative of the universe of Muslim countries. In terms of economic development, the countries included in PISA are fairly developed, such as having medium or high levels of per capita income. It is therefore not surprising that for the countries considered in this study, gender parity ratios in education are at or close to unity. The ages of marriage are slightly higher than other Muslim countries and fertility rates are slightly lower. The gender parity ratios in labor force participation and wage equality appear low but are actually higher than those of less-developed Muslim countries.[3]

3.   Data and methodology

The data for this study comes from PISA, which is an internationally standardized assessment of 15-year-old students in several industrialized and a few developing countries. The PISA survey was jointly developed by ministries of the participating countries and the OECD Secretariat, and implemented in 43 countries in the first assessment in 2000, in 41 countries in the second assessment in 2003, and 57 countries in the third assessment in 2006 (the first time more than two predominantly Muslim countries were included). The sample size from each country is between 4500 and 10,000 students; PISA also collects information on students and their families and schools. PISA uses a two-stage sampling procedure. Once the population is defined, school samples are selected with a probability proportional to school enrolment. Next, 35 students are randomly selected from each school. Since the target population is based on age, the sample includes students from different grades. Students answered questions on personal and family characteristics, and school directors answered questions on school characteristics.[4]

Children with missing data on test scores, gender, and other child-, household-, and school-level characteristics are dropped. The final sample size for each country is 3627 from Azerbaijan, 8364 from Indonesia, 5125 from Jordan, 3911 from the Kyrgyz Republic, 1081 from Qatar, 3037 from Tunisia, and 4325 from Turkey.[5]

As mentioned earlier, the econometric method used in this study is the quantile regression model, which has been used in several economic studies on educational outcomes in industrialized countries (Birch and Miller 2006; Eide and Showalter 1998; Husain and Millimet 2008). The quantile regression model is preferred over ordinary least squares model for two reasons. First, the quantile regression model is more robust to outliers because the weighted sum of absolute deviations gives a robust measure of location on the distribution scale. Second, the quantile regression model produces better estimates by assuming an error term of non-normal distribution, which is particularly suitable for heteroskedastic data such as test-scores.

The quantile regression model is used here to answer two questions. First, for a given achievement distribution in a subject, what is the achievement gender gap if all other personal, family, and school characteristics are identical between boys and girls? Second, do the nature of the gaps vary across the lowest-, low-, median-, high-, and highest-achieving students? In order to focus on the underachievement aspect, it is necessary to control for family characteristics because parents may invest less in girls than boys because of lower expected rates of returns to girls' education than boys'

education or because parents may exert less effort to educate girls (Bonesrønning 2010). In addition, controls for school characteristics are required because schools may treat girls and boys differently.

Drawing from Buchinsky (1998), the simple quantile regression model can be written as:

$$achievement_i = x_i'\beta_\theta + u_{\theta_i}, \; Quant_\theta(achievement_i \mid x_i) = x_i'\beta_\theta$$

where *achievement$_i$* is a student *i*'s test score, and x_i is a vector of explanatory variables, most notably a female indicator or dummy variable (1 if child *i* is a girl and 0 if a boy) and a vector of other child, family, school characteristics; *u* is a mean zero error term.

$Quant_\theta(achievement_i|x_i) = x_i'\beta_\theta$ refers to the conditional quantile of *achievement$_i$*, conditional on the vector of explanatory variables x_i and $\theta \in (0,1)$. It is assumed that $Quant_\theta(u_i|x_i) = 0$. The quantile regression estimates are obtained by minimizing the weighted sum of the absolute values of the errors. Specifically, the θthconditional quantile regression estimator for β is obtained by minimizing the following objective function with respect to β:

$$\sum_{i:achievement_i \geq x_i'\beta}^{N} \theta \left| achievement_i = x_i'\beta_\theta \right| \; + \; \sum_{i:achievement_i < x_i'\beta}^{N} (1-\theta) \left| achievement_i - x_i'\beta_\theta \right|$$

The student, family, and school controls include age, grade, father's education, mother's education, number of books at home, computer at home, school instruction language same as language spoken at home, school having pedagogical autonomy, school facing competition, school reporting performance data publicly, parents having a saying in school budget, public school, percent girls, and school location (rural or urban).

The main shortcoming of the PISA 2006 data is the unavailability of some possibly relevant student variable such as punctuality, behavior, and performance in other subjects, such as the arts, geography, and history. Furthermore, because PISA does not include data on student, family, school, and community views on Islam, this study cannot contribute to the debate on the extent to which commitment to Islam explains educational gender gaps in Muslim countries (King and Hill 1998, 151). Furthermore, this study cannot distinguish the achievements of Muslim and non-Muslim students because PISA does not include information on the child's religion. Another weakness is that PISA does not report information on some key determinants that have been identified on educational gender gaps in industrialized countries, including teacher gender (Dee 2005), labor market expectations (Goldin 1990), and psychological characteristics (Cuffe, Moore, and McKeown 2005). The parity in enrolment rates (discussed in the previous section) suggests that enrolment selection bias is not a shortcoming of the PISA data.

4.   Analyses

Tables 2, 3, and 4 present the gender gaps in mathematics, science, and reading respectively. The tables include the raw or uncorrected gender gaps, which have been

Table 2. Raw gender gaps, and quantile and OLS coefficients on female indicator variable: mathematics.

	N	Raw gap	Quantile regression						OLS	
			0.10 coef.	0.25 coef.	0.50 coef.	0.75 coef.	0.90 coef.		Coef.	
			(SE)	(SE)	(SE)	(SE)	(SE)		(SE)	R^2
Azerbaijan	3627	−2.7	−0.8	−2.7	−1.9	−2.2	−4.1		−2.9	0.106
			(2.9)	(3.1)	(3.0)	(3.5)	(3.9)		(1.8)	
Indonesia	8364	−18.5	−14.0**	−17.1**	−17.0**	−18.5**	−17.2**		−16.9**	0.313
			(5.7)	(4.4)	(4.0)	(5.3)	(6.5)		(2.6)	
Jordan	5125	0.7	−4.7	−4.7	−15.2	−23.5	−19.0		−16.5	0.233
			(24.7)	(19.9)	(19.1)	(14.7)	(17.9)		(11.2)	
Kyrgyz Republic.	3911	−8.0	−3.9	−34.0**	−34.3**	−36.5**	−9.3		−34.2**	0.491
			(5.3)	(5.0)	(4.4)	(5.0)	(5.7)		(2.9)	
Qatar	1081	−14.0	−27.7	3.5	−4.0	6.2	−44.2*		−5.6**	0.230
			(32.8)	(4.0)	(4.4)	(4.7)	(24.3)		(2.5)	
Tunisia	3037	−17.3	−33.5**	−28.5	−41.7**	−37.1**	−38.4**		−36.2**	0.589
			(6.8)	(19.6)	(18.5)	(18.0)	(5.4)		(11.2)	
Turkey	4325	−7.4	−14.1**	−13.5**	−14.9**	−18.7**	20.3**		−16.1**	0.235
			(6.7)	(6.3)	(6.0)	(5.4)	(5.3)		(3.9)	

** and * refer to statistically significance at the 5% level and 10% level respectively.
Note:
1. Raw gap or uncorrected gap = Mean girls' score − Mean boys' score.
2. Standard errors obtained from Balanced Repeated Replicates (this is like bootstrapping except the resamples are pre-defined).
3. All regressions include a constant and the following controls: age, grade, father's education, mother's education, number of books at home, computer at home, school instruction language same as language spoken at home, school having pedagogical autonomy, school facing competition, school providing performance data publicly, parents having a saying with school budget, public school, percent girls, rural, and school dummy variables.
Source: PISA 2006.

Table 3. Raw gender gaps, and quantile and OLS coefficients on female indicator variable: science.

	N	Raw gap	Quantile regression					OLS	
			0.10 coef. (SE)	0.25 coef. (SE)	0.50 coef. (SE)	0.75 coef. (SE)	0.90 coef. (SE)	Coef. (SE)	R^2
Azerbaijan	3627	4.9	8.1** (3.2)	6.0 (3.7)	3.1 (3.7)	1.7 (3.8)	3.1 (4.8)	−2.9 (1.8)	0.106
Indonesia	8364	−13.1	−7.2 (5.2)	−8.1* (4.5)	−10.9** (3.6)	−10.8** (4.2)	8.5 (5.2)	−16.9** (2.6)	0.313
Jordan	5125	22.5	−27.5 (22.8)	−5.9 (17.4)	−2.3 (17.8)	−12.8 (18.9)	−19.7 (17.8)	−16.5 (11.2)	0.233
Kyrgyz Republic	3911	−1.1	6.2 (8.2)	−12.1** (4.4)	−12.1** (4.9)	−14.8** (4.8)	−0.9 (7.2)	−34.2** (2.9)	0.491
Qatar	1081	28.8	−13.2 (32.1)	3.5 (5.1)	2.1 (4.0)	1.2 (3.9)	−34.1 (29.7)	−5.6** (2.5)	0.230
Tunisia	3037	2.7	−11.9* (6.5)	−23.4 (35.1)	−17.9 (19.7)	−16.5 (21.2)	−16.7** (5.4)	−36.2** (11.2)	0.589
Turkey	4325	11.6	10.6 (6.9)	5.6 (5.7)	0.4 (5.5)	−1.4 (4.5)	−2.7 (5.4)	−16.1** (3.9)	0.235

** and * refer to statistically significance at the 5% level and 10% level, respectively.
Note:
1. Raw gap or uncorrected gap = Mean girls' score − Mean boys' score.
2. Standard errors obtained from Balanced Repeated Replicates (this is like bootstrapping except the resamples are pre-defined).
3. All regressions include a constant and the following controls: age, grade, father's education, mother's education, number of books at home, computer at home, school instruction language same as language spoken at home, school having pedagogical autonomy, school facing competition, school providing performance data publicly, parents having a saying with school budget, public school, percent girls, rural, and school dummy variables.
Source: PISA 2006.

Table 4. Raw gender gaps, and quantile and OLS coefficients on female indicator variable: reading.

	N	Raw gap	Quantile regression										OLS		
			0.10 coef.		0.25 coef.		0.50 coef.		0.75 coef.		0.90 coef.		Coef.		R^2
			(SE)		(SE)		(SE)		(SE)		(SE)		(SE)		
Azerbaijan	3627	18.6	24.3**		20.7**		18.3**		15.9**		14.7**		18.4**		0.204
			(6.5)		(4.4)		(4.0)		(4.9)		(5.2)		(2.9)		
Indonesia	8364	16.5	18.3***		18.9**		17.9**		17.0**		15.2**		17.5***		0.341
			(4.9)		(3.7)		(3.8)		(4.9)		(5.6)		(2.2)		
Jordan	5125	47.1	−6.3		3.4		1.3		2.8		−2.8		−1.0		0.292
			(47.8)		(26.6)		(17.4)		(21.2)		(22.2)		(12.7)		
Kyrgyz Republic	3911	44.4	49.8**		18.8**		18.1**		12.2**		36.6**		17.2**		0.460
			(8.1)		(5.5)		(4.8)		(4.7)		(8.5)		(3.7)		
Qatar	1081	59.4	24.8		49.9**		48.2**		44.7**		8.8		46.1**		0.248
			(42.4)		(5.3)		(5.3)		(5.7)		(23.4)		(3.7)		
Tunisia	3037	35.7	19.1**		20.8		20.8		14.4		13.1		13.2		0.521
			(7.8)		(27.5)		(20.9)		(20.2)		(6.8)		(13.8)		
Turkey	4325	42.2	36.2**		35.7**		27.6**		20.9**		20.3**		29.2**		0.241
			(8.5)		(6.2)		(5.5)		(5.3)		(5.3)		(4.0)		

** and * refer to statistically significance at the 5% level and 10% level respectively.
Note:
1. Raw gap or uncorrected gap = Mean girls' score − Mean boys' score.
2. Standard errors obtained from Balanced Repeated Replicates (this is like bootstrapping except the resamples are pre-defined).
3. All regressions include a constant and the following controls: age, grade, father's education, mother's education, number of books at home, computer at home, school instruction language same as language spoken at home, school having pedagogical autonomy, school facing competition, school providing performance data publicly, parents having a saying with school budget, public school, percent girls, rural, and school dummy variables.
Source: PISA 2006.

calculated simply by subtracting the mean scores of girls from the mean scores of boys as reported in Appendix Table 1. Raw gender gaps, however, cannot be used to address underachievement because it is possible that personal, family, and school characteristics differ by gender. The issue of underachievement (or overachievement) can only be addressed when other personal, family, and school characteristics are identical for boys and girls.

Table 2, 3, and 4 also present the coefficients of the female indicator variable obtained from quantile regression and (for illustrative purposes) OLS regression analyses. The OLS coefficients measure the gender gap on average, and the quantile regression coefficients measure the gender gap in the 0.10 quantile (lowest achievement), 0.25 quantile (low achievement), 0.50 quantile (median achievement), 0.75 quantile (high achievement), and 0.90 quantile (highest achievement) distributions of student achievement scores. The female indicator coefficients measure the educational gender gap after adjusting the scores so that all other characteristics are exactly the same for girls as they are for boys; thus, the coefficients provide information on the extent that girls are achieving differently than boys, correcting for differences in their families and schools. The interpretation of quantile regression estimation results is complex because quantile coefficients tell us about effects on distributions, not individuals (Angrist and Pischke 2009, 281). Thus, the rank of students remains unchanged because students remain in the same quantiles. For example, a statistically significant female indicator coefficient on in quantile 0.50 tells us that within quantile 0.50, girls have a higher score than boys in quantile 0.50, holding all else constant.[6]

It is possible to conduct hypothesis tests of equality of the regression coefficients at different conditional quantiles; this test is informative because the difference of gaps across the distribution is the main justification for using quantile regression rather than OLS. There are several steps involved in the hypothesis test. First, the full covariance matrix of coefficients has to be obtained. Since the test requires the bootstrap, the seed and number of bootstrap replications have to be set. Next, a Wald test is conducted to test the hypothesis that the coefficients on gender are the same for the five quantiles (that is, 0.10, 0.25, 0.50, 0.75, and 0.90). Finally, if the computed F value is greater than the critical F value, the hypothesis that gender coefficients are equal is rejected.

4.1. *Gender gaps in mathematics achievement*

The raw or uncorrected gender gaps in Table 2 suggest that there are pro-male gaps in mathematics achievement in Indonesia (18.5 points), the Kyrgyz Republic (8.0 points), and Tunisia (17.3 points). The differences in raw scores indicate that there are no cases of large pro-female gaps in mathematics achievement, but the non-significant values from Azerbaijan, Jordan, Qatar, and Turkey suggest that there are no gender gaps in mathematics achievement.

The quantile regression analyses shows mixed results on girls' achievement in mathematics relative to that of boys. The statistically insignificant coefficients of the female indicator variables for the student samples from Azerbaijan and Jordan provide no evidence of girls achieving worse than boys in mathematics. The negative and statistically significant coefficients across all quantiles in Indonesia (14–18.5 points) and the Kyrgyz Republic (34–36.5 points) suggest that girls achieve more poorly in mathematics than boys. In Qatar, underachievement is restricted to girls among the

highest achievers (44.2 points). In Tunisia, there is evidence from the median quantile and onwards that girls underachieve (37.1–41.7 points).

Post-estimation tests show that the quantile regression coefficients for the gender dummy are different across quantiles. The null hypothesis of coefficient equality is rejected at the level of 0.050 for Azerbaijan (Prob > F = 0.784), Indonesia (Prob > F = 0.059), Jordan (Prob > F = 0.630), Kyrgyz Republic (Prob > F = 0.315), Qatar (Prob > F = 0.741), Tunisia (Prob > F = 0.624), and Turkey (Prob > F = 0.648). Thus, there is a statistical ground for using quantile regression instead of OLS regression in analyzing gender gaps in mathematics.

4.2. Gender gaps in science achievement

The raw or uncorrected gender gaps in science achievement shown in Table 3 indicate that there are pro-female gaps in Azerbaijan (4.9 points), Jordan (22.5 points), and Turkey (11.6 points). In contrast, there is a pro-male science gender gap in Indonesia (13.1 points). There are small pro-female gap in Kyrgyz Republic (1.1 points) and pro-male gap in Tunisia (2.7 points).

The quantile regression coefficients in Table 3 provide no evidence that girls achieve more poorly in science in Jordan, Qatar, Tunisia, and Turkey. In Azerbaijan, only girls in the lowest quantile underachieve in science (8.1 points), and in Tunisia, underachievement is restricted to girls in the lowest and highest quantiles (11.9 and 16.7 points); thus, girls' underachievement in Azerbaijan and Tunisia are restricted to the extremes of the performance distribution. There is evidence of girls underachieving in science in Indonesia (8.1–10.9 points) and the Kyrgyz Republic (12.1–14.8 points) in all but the lowest and highest quantiles, suggesting that underachievement is typical across most of the science achievement distribution.

A comparison of the raw gender gaps and quantile regression coefficients provides evidence that families and schools are more supportive of girls' science endeavors than boys' science endeavors. Specifically, the raw gender gaps in Azerbaijan, Jordan, the Kyrgyz Republic, Qatar, and Turkey are positive and considerably larger than that of the quantile regression coefficients. Such results provide further evidence that girls in these six countries may be underachieving in science.

Further tests confirm that the quantile regression coefficients for the gender dummy are different across quantiles. The null hypothesis of coefficient equality across the quantiles is rejected at the level of 0.050 for Azerbaijan (Prob > F = 0.139), Indonesia (Prob > F = 0.084), Jordan (Prob > F = 0.630), Kyrgyz Republic (Prob > F = 0.136), Qatar (Prob > F = 0.547), Tunisia (Prob > F = 0.769), and Turkey (Prob > F = 0.109). Like the previous case of gender gaps in mathematics achievement, there is statistical justification for the use of quantile regression analysis for examining gender gaps in science.

4.3. Gender gaps in reading achievement

The raw gender gaps in reading achievement are presented in Table 4. Remarkably, there are enormous pro-female gaps in all seven countries: Azerbaijan (18.6 points), Indonesia (16.5 points), Jordan (47.1 points), the Kyrgyz Republic (44.4%), Qatar (59.4 points), Tunisia (35.7 points), and Turkey (42.2 points). Thus, the magnitudes of these raw gaps are far larger than raw gaps observed for mathematics or science.

According to the quantile regression estimates of reading achievement in Table 4, there is little or no statistically significant evidence that girls achieve differently than boys in Jordan and Tunisia. There is evidence of girls achieving better than boys in Azerbaijan (15.9–20.7 points) and Indonesia (17–18.9 points). The size of girls' over-achievement in reading is largest in Qatar (44.7–49.9 points). As in the case of mathematics and science, the OLS estimates for reading are close to the median esti-mates of the quantile regression analyses. In addition, the magnitude of the raw gaps and quantile regression gaps are comparable.

The null hypothesis of coefficient equality in reading across the achievement distribution is rejected at the level of 0.050 for Azerbaijan (Prob > F = 0.176), Indonesia (Prob > F = 0.864), Jordan (Prob > F = 0.502), Kyrgyz Republic (Prob > F = 0.537), Qatar (Prob > F = 0.811), and Tunisia (Prob > F = 0.174). However, the null hypothesis is not rejected for Turkey (Prob > F = 0.011). Overall, the test results show that there is a strong statistical basis for using quantile regression rather than OLS in analyzing gender gaps in reading.

5.   Discussion

The results of this study indicate that there is some evidence that girls achieve more poorly than boys in mathematics and science, and achieve better than them in reading. These findings are consistent with historical and recent evidence from industrialized countries. From casually observing the country characteristics in Table 1 and the OLS and quantile regression results, there appears to be no relationship between girls' academic achievement and key country-level economic and social characteristics such as per capita income, economic growth rate, average age of marriage, fertility rates, and labor market gender gaps. The results for Qatar compared to Azerbaijan and Jordan suggest that girls' academic achievements can be impressive in countries with very different levels of economic development. Jordan also has the highest levels of fertility rates and labor market disadvantage, and yet girls do not underachieve in mathematics, science, and reading. Similarly, there are no clear regional trends. Among the Middle Eastern and North African countries, there is no evidence of girls underachieving in Jordan, though there are cases of mathematics underachievement in Tunisia and to a lesser extent Qatar. Between the two Central Asian countries, there is no evidence of girls underachieving in Azerbaijan, although girls in the Kyrgyz Republic underachieve in mathematics.

How do girls' academic achievements in the seven Muslim countries differ from achievements in industrialized non-Muslim countries such as the USA and UK? Given that the USA and UK have large service sector opportunities for women, a high degree of women's rights, and easy access to birth control, we may expect that girls' under-achievement to be rare. The large body of research from the USA and UK, however, shows that girls frequently achieve worse than boys in mathematics, achieve as well as boys in science, and achieve better than boys in reading (Eccles and Jacobs 1986; Mickelson 1989; Weinburgh 1995).[7]

There are other issues that cannot be addressed in this study because of data limi-tations. For example, because this study only documents the achievements of 15-year-old girls, there is no way of assessing whether the nature of girls' achievement varies across age-groups in a given country. Furthermore, the psychological and behavioral characteristics of students are not examined in this study, even though existing social science research shows that such characteristics are determinants of academic

achievement. Evidence from industrialized countries show that relative to boys, girls mature earlier, and are more likely to show patience and seriousness with homework (Duckworth and Seligman 2006); moreover, girls are less likely to have school disciplinary and behavior problems and much less likely to suffer from attention deficit hyperactivity disorder (ADHD) (Cuffe, Moore, and McKeown 2005; Silverman 2003). Accordingly, these psychological and behavioral characteristics imply that girls should achieve better than boys academically, holding all else constant. Since these characteristics are not controlled for in the analyses, the conclusions about girls' underachievement in this study may be strengthened further if the data for these characteristics in Muslim countries are similar to those in the West and North.

Despite the limitations, there are policy implications that can be drawn from this study. Since PISA 2006 measures cognitive skills, likely result of not correcting underachievement, whether of boys or girls, is that the economy is deprived of skilled workers. The experiences of industrialized countries indicate that media campaigns are a useful method of encouraging girls to study advanced mathematics and science in secondary school, and to pursue mathematics and science-related college degrees and careers (National Academy of Sciences 2006). Similarly, interventions for improving boys' reading may include media campaigns directed at boys, male reading groups, and assigning adult men as reading mentors (Brozo 2006).

Finally, the rich research from industrialized countries provides guidance on future research in these seven and other predominantly Muslim countries. In the spirit of Dominitz and Manski (1996), expectations about their economic, social, and cultural conditions can be elicited from students to understand better the reasons for girls' academic achievements. Another pertinent direction for future research is the measurement of the private and social costs of academic underachievement. For example, how much does underachieving by 10 points in a given subject affect an individual's lifetime earnings and health? What implications does this have on the costs of public assistance? Emerging studies on the USA provide clues on data and methodological requirements on linking childhood academic achievement and future outcomes (Muennig 2007; Rouse 2004, 2007; Wilson 2001).

6.   Conclusions

This study examined girls' academic achievement relative to boys in seven predominantly Muslim countries: Azerbaijan, Indonesia, Jordan, the Kyrgyz Republic, Turkey, Tunisia, and Qatar. In particular, the study investigates how girls' achieve relative to boys if all other child, family, and school level characteristics are similar. The quantile regression analyses indicate that girls do best in Azerbaijan, where there are no cases of girls underachieving in mathematics and science, and cases of girls overachieving in reading. Next is the case of Jordan, where there is no evidence of girls overachieving or underachieving. Girls in Qatar and Turkey underachieve in mathematics but do as well as boys in science, and overachieve in reading. Lastly, girls do worst in Indonesia the Kyrgyz Republic, and Tunisia, where girls underachieve in mathematics and science, and overachieve in reading. Overall, the null hypothesis of gender dummy coefficient equality across quantiles at the 0.05 level is rejected in every subject and country with the exception of reading in Turkey. Thus, there is strong statistical justification for the use of quantile regression rather than OLS regression, such that it reveals that the magnitude of gender gap coefficient vary considerably across achievement quantiles for a given subject. However, there is no

evidence that the direction of the gender gap coefficient vary across quantiles for a given subject.

On the basis of the analyses, two generalizations can be made about girls' academic achievement in the seven Muslim countries. First, a casual look at key country-level economic, social, and cultural characteristics appear unrelated to girls' achievement in mathematics, science, and reading. Second, girls frequently over-achieve in reading and do not overachieve in mathematics and science. Therefore, despite more challenging economic, social, and perhaps cultural conditions, the nature of girls' academic achievements relative to boys are not all that different between the seven Muslim countries and non-Muslim industrialized countries (Mickelson 1989).

Acknowledgements

Notes

1. There are basic descriptive statistics on gender gaps in the countries considered here, such as the Organization for Economic Co-operation and Development (OECD) report *Equally Prepared for Life? How 15-Year-Old Boys and Girls Perform in School* (OECD 2009a). As for econometric studies, Indonesia and Turkey are the notable exceptions because a rich body of economic literature on education exists; see Tansel (2002) and Deolalikar (1993) among others. To my knowledge, there are no econometric studies of educational gender gaps in Azerbaijan, Jordan, the Kyrgyz Republic, Tunisia, and Qatar. There are econometric studies of gender gaps in Muslim countries not covered in this study. Shafiq (2009) found that enrolment and attainment gap has reversed in Bangladesh. Hajj and Panizza (2009) found that among Muslim children in Lebanon, girls received more years of education than boys; the authors concluded that there was no support for the hypothesis that Muslims discriminate against female education in Lebanon. In Muslim communities of India (a country where 13% of population is Muslim), Borooah and Iyer (2005) found pro-male gaps. Among the rare studies that examine achievement in subjects, Tansel and Bircan (2005) examine university entrance scores in Turkey and find pro-male gaps in mathematics and science scores but a pro-female gap in language scores.
2. Sex-selective abortions or female infanticide may mean that there are more serious gender gap issues in each of the countries. However, official sex ratio statistics (that is, ratio of total males to total females) do not suggest that female infanticide is widely practiced in Indonesia, Jordan, Qatar, Tunisia, and Turkey; however, the sex ratio for Azerbaijan is troubling. The official sex ratios (males/females) at birth are 1.13 in Azerbaijan, 1.05 in Indonesia, 1.06 in Jordan, 0.96 in the Kyrgyz Republic, 1.06 in Qatar, 1.07 in Tunisia, and 1.05 in Turkey (CIA n.d.).
3. Figures for other Muslim countries are not included because the *Global Gender Gap Report* is not exhaustive with respect to country coverage. In particular, the poorest and politically unstable Muslim countries are not included because of data unavailability. Examples include Afghanistan and several countries in Sub-Saharan Africa.
4. For the mathematics problems in PISA, students are required to identify features of a problem that might involve thinking in terms of mathematics. In turn they use their knowledge of mathematics to solve the particular problem. Four different aspects of mathematics were tested: space and shape; change and relationships; quantity; and uncertainty. The reading components involved written information provided in a real-life context. Students are shown different kinds of written text, ranging from prose to lists, graphs and diagrams. They are then set a series of tasks, requiring them to retrieve specific information, to interpret the

text and to reflect on and evaluate what they read. These texts are set in a variety of reading situations, including reading for private use, occupational purposes, education and public use. Finally, the science component also included the application of scientific knowledge and skills to real-life situations, as opposed to science linked to particular curricular components. Students are required to show a range of scientific skills, involving the recognition and explanation of scientific phenomena, the understanding of scientific investigation and the interpretation of scientific evidence. Science tasks are set in a variety of contexts relevant to people's lives that include life and health, technology and the Earth and environment (OECD 2009b).

5. The original sample sizes are as follows: 5184 from Azerbaijan, 10,647 from Indonesia, 6509 from Jordan, 5904 from the Kyrgyz Republic, 6265 from Qatar, 4640 from Tunisia, and 4942 from Turkey.

6. The usual method of calculating standard errors is biased for two reasons. First, there is intra-cluster correlation among schools. To correct for the effect of intra-cluster correlation, PISA provides a series of weights for Balanced Repeated Replicates (BRR), which is like bootstrapping except the resamples are pre-defined. When calculating standard errors of variables except for those derived from the plausible values, Stata's svyset command allows the use of BRR methodology (called a Fay's adjustment, which, in the case of PISA 2006, is 0.5). Second, there is no single estimate for the dependent variable, but five plausible values. Thus, the standard error has to take into account the sampling variance in the estimate of the dependent variables.

7. Mathematics gender gaps in the USA have narrowed since 1990 (Hyde et al. 2008).

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Appendix

Table 1.   Raw achievement by subject and gender.

		Mathematics		Science		Reading	
		Girls	Boys	Girls	Boys	Girls	Boys
		Mean	Mean	Mean	Mean	Mean	Mean
	N	(SD)	(SD)	(SD)	(SD)	(SD)	(SD)
Azerbaijan	3627	478.3	481.0	391.5	386.6	369.4	350.8
		(42.7)	(45.0)	(50.8)	(53.9)	(61.2)	(67.2)
Indonesia	8364	386.3	404.8	390.3	403.4	405.4	388.9
		(71.9)	(77.8)	(63.9)	(69.0)	(66.9)	(72.1)
Jordan	5125	396.4	395.7	444.7	422.2	436.0	388.9
		(66.8)	(78.2)	(69.5)	(84.7)	(69.5)	(86.1)
Kyrgyz Republic	3911	311.9	319.9	327.2	328.3	310.3	265.9
		(74.2)	(80.8)	(72.9)	(78.8)	(85.5)	(94.4)
Qatar	1081	371.7	357.7	396.5	367.7	373.2	313.8
		(101.7)	(110.9)	(86.0)	(98.0)	(103.3)	(120.7)
Tunisia	3037	364.3	381.6	393.2	390.5	406.2	370.5
		(84.1)	(87.4)	(76.8)	(79.6)	(81.6)	(94.2)
Turkey	4325	425.3	432.7	433.8	422.2	474.6	432.4
		(83.7)	(90.7)	(76.4)	(82.4)	(75.2)	(87.9)

Notes: Samples are evenly split between boys and girls and weighted following PISA guidelines.
Source: PISA 2006.